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PRIOR MAMMOGRAPHY UTILIZATION: DOES IT EXPLAIN BLACK-WHITE DIFFERENCES IN BREAST CANCER OUTCOMES?

AN ABSTRACT
SUBMITTED ON THE FIFTH DECEMBER, 1996
TO THE DEPARTMENT OF BIOSTATISTICS AND EPIDEMIOLOGY
OF THE GRADUATE SCHOOL OF
TULANE UNIVERSITY
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF
DOCTOR OF PHILOSOPHY
BY

Ellen Patricia McCarthy, MPH

APPROVED:

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ABSTRACT

Black women are more likely to be diagnosed with advanced stage breast cancer and experience worse survival than whites possibly because blacks receive fewer mammograms. To investigate whether regular mammography use can explain the observed black-white difference in stage at diagnosis and survival, we undertook a study using the Linked Medicare-Tumor Registry Database.

The study sample included black and white women age $\geq$ 67 diagnosed with breast cancer, from 1987-1989, in three Surveillance, Epidemiology, and End Results tumor registries. Women were classified based on their mammography use during the 2 years before diagnosis: nonusers (no prior mammograms), regular users (at least 2 mammograms at least 10 months apart), or peri-diagnosis users (only mammogram(s) within 3 months before diagnosis). Stage was classified as early (in situ/local) or late (regional/distant). Women whose mammography use could not be categorized (n=292) or whose disease was unstaged (n=141) were excluded.

Mean age at diagnosis for the 4,005 women was 76, 4% were black, 37% married, and 16% lived in an area with a median income < $15,000; 48% resided in Connecticut, 35% in Seattle, and 17% in Atlanta. One-quarter (23%) of women were nonusers,

19% regular users, and 58% peri-diagnosis users of mammography. One-third of women were diagnosed with late-stage disease. Blacks were more likely to be nonusers of mammography (OR=3.0, 95% CI 2.4-3.8) and were more likely to be diagnosed with late-stage disease (OR=2.5, 95% CI 1.6-4.0) than whites. This black-white difference is related to mammography use in that blacks who were nonusers were significantly more likely to be diagnosed with late-stage disease than black regular users (OR=6.7, 95% CI 1.8-27.4); and that blacks and whites who were users were diagnosed at a similar stage (OR=1.05, 95% CI 0.3-3.4). Prior mammography use explained nearly 30% of the excess late-stage disease among blacks. Blacks experienced a higher risk of death relative to whites (RR=1.5, 95% CI 1.1-2.1). Prior mammography use reduced the estimated relative risk of black race to (RR=1.3, 95% 0.9-1.8).

Black women benefit from regular mammography use by being diagnosed with earlier stage disease. These findings suggest that differences in breast cancer outcomes is not strongly linked to race, but is rather an issue of whether a woman receives regular mammograms.

PRIOR MAMMOGRAPHY UTILIZATION: DOES IT EXPLAIN BLACK-WHITE DIFFERENCES IN BREAST CANCER OUTCOMES?

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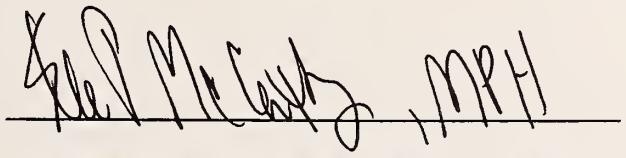

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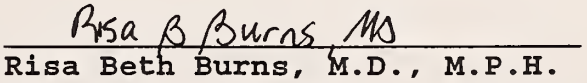

Risa Beth Burns, M.D., M.P.H.

For my grandparents

John and Sarah
Francis and Catherine

For my parents

Joseph and Kathleen

with love

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I am eternally grateful to Dr. Risa Beth Burns for her dedication, guidance and constant encouragement throughout my dissertation. She provided invaluable clinical and methodologic expertise as well as motivation at virtually every stage of this dissertation.

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INTRODUCTION

The purpose of this dissertation research is to determine the extent to which black-white differences in breast cancer outcomes among elderly women can be accounted for by differential mammography utilization prior to breast cancer diagnosis. Black women experience worse breast cancer survival and are more likely to be diagnosed with advanced stage disease as compared with white women. Furthermore, black women are less likely to receive screening mammography than white women. However, the question remains unanswered as to whether differences in prior mammography use account for these black-white differences in breast cancer outcomes.

This study is the first to examine black-white differences in breast cancer outcomes and to determine if prior mammography use helps to explain these differences. The study overcomes the limitations of prior research. Information is available with which to construct longitudinal histories of mammography use for elderly women prior to their breast cancer diagnosis.

This study used the Linked Medicare-Tumor Registry Database created by the National Cancer Institute (NCI) and the Health Care Financing Administration (HCFA). The linked

database contains information on women age 65 and older who are diagnosed with breast cancer from three population-based tumor registries, including information on prior mammography use, breast cancer characteristics and breast cancer outcomes.

Objectives

The goal of this study is to: (1) broaden our understanding of mammography utilization among elderly black and white women prior to their breast cancer diagnosis (at age 67 years and older); and (2) relate prior mammography use to black-white differences in breast cancer outcomes.

This study used the Linked Medicare-Tumor Registry Database[1] created by the National Cancer Institute (NCI) and the Health Care Financing Administration (HCFA) to achieve the following objectives:

1) Describe prior mammography utilization and factors associated with prior use among black and white women who are diagnosed with breast cancer at age 67 or older.
2) Describe the relationship between prior mammography utilization and stage at diagnosis for black and white women.
3) Describe the relationship between prior mammography utilization and survival for black and white women.

4) Determine how much of the black-white difference in stage at diagnosis is explained by differences in prior mammography use.

5) Determine how much of the black-white difference in survival is explained by differences in prior mammography use.

Hypothesis

Since black women are less likely than white women to receive mammography prior to their breast cancer diagnosis, and since prior mammography use is associated with positive breast cancer outcomes, it is reasonable to hypothesize that differences in prior mammography use may account for at least some of the black-white difference in breast cancer outcomes after adjusting for other known prognostic factors.

CHAPTER I

LITERATURE REVIEW

Background

Breast Cancer Incidence

Breast cancer is an important public health problem in the United States. It is the most commonly diagnosed cancer among women. One in every eight women will develop breast cancer in her lifetime.[2] Breast cancer is second only to lung cancer as the leading cause of cancer mortality in women.[2] More health care dollars are spent on breast cancer than any other cancer in women (6.5 billion in 1990).[3]

The risk of developing breast cancer increases with age, and the greatest burden of the disease is borne by women age 65 and older.[4] These women account for more than 43% of newly diagnosed cases of breast cancer and have twice the mortality rate of younger women.[5] Data from the NCI's Surveillance, Epidemiology, and End Results (SEER) Program show that the incidence rate for invasive breast cancer among women age 65 and older was considerably higher than the rate observed among women under age 65 during the period 1986 to 1990 (440 per 100,000 versus 72 per 100,000, respectively).[6] Breast cancer incidence rates also increase with advancing age until

approximately age 85 when the incidence rates decrease and plateau.[6]

Table 1. Invasive Breast Cancer Incidence Rates by Race

SEER Rates per 100,000, 1987-1991[6]

Age at Diagnosis	Black	White	All Races
65-69	325	430	412
70-74	336	469	450
75-79	367	503	484
80-84	379	491	477
85+	333	441	428

Table 1 shows the SEER incidence rates for breast cancer among elderly women.[6] The incidence of breast cancer is higher for elderly white women as compared with elderly black women in each age group.[6,7] The age-specific incidence rates from 1987 to 1991 among white women aged 65 to 69 years, 70 to 74 years, 75 to 79 years, 80 to 84 years and 85+ years were 430 per 100,000, 469 per 100,000, 503 per 100,000, 491 per 100,000, and 441 per 100,000, respectively. Among black women, the age-specific incidence rates during the same time period are 325 per 100,000, 336 per 100,000, 367 per 100,000, 379 per 100,000, and 333 per 100,000 for women aged 65 to 69, 70 to 74 years, 75 to 79 years, 80 to 84 years, and 85+ years, respectively.[6]

Breast Cancer Incidence Trends

Breast cancer incidence rates increased rapidly between 1980 and 1987.[6] Greater use of mammography during this time period is thought to be partly responsible for the increase in breast cancer incidence rates.[8,9] The observed rise in breast cancer incidence is primarily characterized by increased detection of carcinoma in situ, smaller tumors and localized lesions.[8,9] Mammography detects tumors earlier in the disease process when they are smaller in size. Rates for localized tumors increased by 52% between 1982 and 1989, while rates for regional or distant tumors decreased 9% and 10%, respectively.[2]

The observed shift towards early (in situ and localized) stage disease has been documented for both black and white women,[10,11] however, the shift for black women was not as great as the shift for white women.[9,11] For example, white women over age 50 experienced a greater increase in incidence of early stage disease from 1980 to 1987 as compared with their black counterparts (38% and 26%, respectively).[6] Swanson et al. examined the changes in patterns of stage of disease for black and white women diagnosed with breast cancer using SEER data from 1983 to 1989.[9] They found increased rates of smaller and less-invasive tumors that are consistent with screening (e.g., ductal carcinoma in situ and small-sized tumors without axillary node involvement) for both black and white women. However, white women experienced a greater

increase in incidence of ductal carcinoma in situ, the least invasive lesion as compared with black women over the period 1983 to 1989 (213% versus 153%, respectively). In summary, these data support the hypothesis that the observed rise in breast cancer incidence during the 1980s is primarily due to increased mammography utilization. Furthermore, these data suggest that mammography screening is lower among black than white women.[9]

Breast Cancer Stage at Diagnosis

The stage of breast cancer at time of diagnosis is the most important predictor of prognosis. Women who are diagnosed while their cancer is localized (i.e., the tumor is confined to the breast) experience better five-year relative survival rates as compared with women diagnosed with regional (i.e., tumors that involve axillary lymph nodes) or distant (i.e., tumors that have metastasized to other organs and tissues) disease.[5] The five-year survival rates for women aged 65 to 74 years, 75 to 84 years, and 85+ years who are diagnosed with localized disease are 91%, 90% and 83%, respectively.[5] In contrast, the five-year survival rates for women of these same three age groups who are diagnosed with distant disease are 17%, 20% and 16%, respectively.[5]

Older women are not only at increased risk of developing breast cancer as compared with younger women, but they are also more likely to present with distant disease.[5,12] Nearly

half (48%) of women who present with metastatic (distant) breast cancer are 65 years or older.[5] Furthermore, black women are diagnosed more often with late-stage (i.e., regional and distant) disease as compared with white women.[13] Among women aged 50 years and older, blacks are disproportionately under-represented among those diagnosed with localized disease when compared with whites (45% versus 57%) and over-represented among those diagnosed with regional (38% versus 32%) and distant (11% versus 7%) disease.[6] Other factors that are associated with late-stage at diagnosis include lower socioeconomic status (SES), less education, being unmarried and public hospital setting.[5,13,14,15,16,17]

Breast Cancer Mortality

Breast cancer mortality rates among women over age 60 have increased, however, the overall mortality rate from breast cancer has remained stable since 1973.[18] Although the incidence of breast cancer is lower for black women, their breast cancer mortality rates are higher than those of white women. SEER data from 1983 to 1990 demonstrate that the 5-year relative survival for white and black women over age 65 are 83% and 67%, respectively.[6] Furthermore, from 1980 to 1987, breast cancer mortality rates increased 5%, 12%, and 8% for white women aged 60 to 69 years, 70 to 79 years, and over 80 years, respectively. The increase in mortality among elderly black women was even greater, 17%, 20%, and 18% for

those aged 60 to 69 years, 70 to 79 years, and over 80 years, respectively.[18]

The results of previous studies indicate that the excess mortality among black women is in part explained by their advanced stage at diagnosis.[19,20] In fact, black and white women diagnosed with localized disease have been found to have a similar survival rate.[21] This suggests that black and white women would benefit equally from screening mammography.

Breast Cancer Screening

Breast cancer mortality can be reduced through early detection. Mammography is thought to be the most effective method available for detecting breast cancer at an early (in situ or localized) stage.[22] Prior studies have shown that screening mammography reduces breast cancer related mortality 20% to 39% among women aged 50 to 74 years.[23]

Despite this striking reduction in mortality, mammography remains underutilized by certain populations. Women who are older, black, less educated, or come from lower socioeconomic backgrounds are less likely to undergo screening mammography.[7,24] Such women are also more apt to be diagnosed with advanced stage breast cancer.[12,25]

Mammography utilization is greatest among women in their fifties and then declines with advancing age.[26] Results from the 1987 National Health Interview Survey reveal that 44% of women aged 50 to 59 years reported that they had ever used

mammography in their lifetime, whereas 38% of women aged 60 to 69 years, and 28% of women aged 70+ years had ever used mammography.[26] This pattern persisted in the 1992 National Health Interview Survey even though mammography rates increased for women of each age group; 75% of women aged 50 to 59 years, 68% aged 60 to 69 years, and 58% aged 70+ years had ever used mammography.[26] Similar trends were reported in other national surveys including the 1990 and 1992 Mammography Attitudes and Usage Survey[27] and the 1990 Behavioral Risk Factor Surveillance System.[28]

The use of screening mammography has increased over time among older women. Results from the 1987 and 1992 National Health Interview Surveys show that the proportion of women aged 60 to 69 years who reported having had a mammogram during the previous year increased from 17% to 33%.[26] Recent Medicare data indicate that mammography use among elderly women increased slightly from 1991 (24%) to 1993 (25%).[29]

The lower mammography use among older women may reflect the lack of consensus among professional organizations regarding breast cancer screening in older women. Annual mammography is recommended by the American Cancer Society[30] and the American Medical Association Council on Scientific Affairs[31] for women after age 50. Annual to biennial mammography is recommended by the United States Preventive Services Task Force for women aged 50 to 74 years.[32] Annual mammography is recommended for women aged 65 to 74 years by

the Forum on Breast Cancer Screening in Older Women.[33] The Forum also suggests that mammography "should be encouraged" at regular intervals of approximately every two years for women aged 75 years and older whose general health and life expectancy are good.[33]

Lower mammography utilization among black women has been documented in national surveys.[27,34] Results from the 1990 Mammography Attitudes and Usage Survey (MAUS) of women aged 40 years and older demonstrate that 35% of whites and 42% of blacks had never had a mammogram.[27] In the 1992 MAUS survey, the proportion of white women who never had a mammogram decreased to 24%, whereas the proportion of black women who never had a mammogram remained at 41%.[27] Results from the 1987, 1990, and 1992 National Health Interview Surveys also indicate that black women reported having a screening mammogram less often than white women.[26,34] In 1987, only 13% of black women and 17% of white women aged 65 to 69 years reported that they had had a mammogram within the previous 12 months.[34] This increased to 29% and 36% for black and white women of the same age group in 1990.

Particularly low screening rates were observed for elderly women aged 80+ years in the 1987 and 1990 National Health Interview Survey.[34] In 1987, only 3% of black and 8% of white women aged 80+ years had a mammogram within the previous 12 months.[34] This increased to 22% and 17% for elderly black and white women of the same age group in 1990.[34]

Prior Research

Black-White Differences in Mammography Utilization

Even though differences in mammography rates for black and white women have narrowed over time,[26,34] black-white differences in mammography continue to persist among women over the age of 65 years.[29,35,36] Black-white differences in mammography use have been observed in the elderly (aged 65 years and older) using Medicare physicians' claims data.[29,35,36,37] Escarce et al. found that the age-adjusted rate of mammography among elderly white women was 1.76 times that of elderly black women using 1986 claims data.[37] Trontell used Medicare physicians' claims data to estimate rates of mammography use from 1991 to 1993.[29] Table 2 presents her results for mammography utilization in 1993 for approximately 16 million women on Medicare. Similar results were observed for 1991 and 1992. She found that black women enrolled in Medicare were less likely than their white counterparts to have received mammography in each age group. Although the racial difference declined over the three year period, black women continued to have less mammography than white women.[29] For example, among women aged 65 to 69 years, whites were more likely than blacks to have had a mammogram (35% versus 24%, respectively). Although the overall mammography rate was generally low (< 7% in each year) among women age 85 and

older, white women were still more likely to use mammography than black women (7% versus 6%, respectively).[29]

Table 2. Percentage of Women Aged ≥ 65 Years who had a Mammogram by Race Medicare Claims Data, 1993[29]

Age Group	% Black (n=1,181,612)	% White (n=13,740,507)	% All Races (n=15,852,556)
65-69	24	35	34
70-74	22	32	31
75-79	17	25	24
80-84	12	17	16
85+	6	7	6
Total	18	26	25

Blustein examined whether mammography utilization in elderly women covered by Medicare differed according to supplemental health insurance status.[35] She used physicians' claims data from 1991 and 1992 on a nationally representative sample of women who participated in the Medicare Beneficiary Survey. Linking mammography claims with survey information, she classified women into four insurance categories: Medicare only, Medicare plus Medicaid supplemental insurance, Medicare plus employer-sponsored supplemental insurance, and Medicare plus self-purchased supplemental insurance. Mammography use was lower for black women in each year and for both years combined. Only one-quarter of black women and 39% of white women had a mammogram performed in the two-year time period. Mammography use also varied according to insurance status for

black and white women. Women who lacked supplemental insurance were the least likely to use mammography. Moreover, black women were less likely than white women to have had a mammogram during the two-year period within each category of supplemental insurance.[35]

We recently completed two studies that used Medicare physicians' claims data to examine mammography utilization in 1990 among women age 65 and older residing in ten states.[36,38] Since little is known about the factors associated with mammography use among older women, our first study was designed to explore factors associated with mammography use in women within three age groups: 65 to 74 years, 75 to 84 years, and 85+ years.[38] Overall, only 15% of women had a mammogram in 1990. Rates of mammography use declined with advancing age: 20% of women aged 65 to 74 years, 12% of those aged 75 to 84 years, and 4% of those aged 85+ years. Mammography use was lowest in Oklahoma and highest in Washington state. However, in each state, mammography use decreased with advancing age group. Mammography use was lower for black women aged 65 to 74 years (14% versus 21%) and aged 75 to 84 years (9% versus 12%) as compared with white women. Women in each of these two age groups had lower mammography use if they resided in the lowest income quintile and higher use if they resided in the highest income quintile (17% versus 23% 65 to 74, and 10% versus 13% 75 to 84). Among the oldest women (those aged 85+ years), mammography use was low (4%) and varied minimally by

race and income. In all age groups, mammography use was lowest among women who did not have a primary care visit, greater among women who had at least one visit and continued to rise with increasing number of visits. We found that mammography use was less for women who were older, of black race, who did not visit a primary care provider and who lived in areas with lower median income and certain states. Similar factors influenced mammography use in women aged 65 to 74 years, where there is greater consensus as to who should receive a mammogram, as in women aged 75 to 84 years where there is little consensus. Surprisingly, neither race nor income had much influence on mammography use among women aged 85 years and older.[38]

We conducted a second study to broaden our understanding of the observed black-white differences in mammography use among women age 65+ years who were on Medicare, and to examine the extent to which black-white differences in mammography use are explained by number of primary care visits.[36] The following are findings from Georgia; a similar picture was found in each of the states studied. The mean age for the 335,680 women was 75 and 20% were black. Two-thirds of black (68%) and white (69%) women had at least one primary care visit. Overall, 14% of women had a mammogram; the rate was less for black women (9% versus 15%). At each primary care visit level, black women received mammograms less often than white women [1 visit (7% versus 15%), 2 visits (12% versus

21%), and 3+ visits (12% versus 20%)]. Even among women with at least one primary care visit, the deficit for black women persisted within each income quintile [lowest (13% versus 20%), moderately low (10% versus 18%), middle (12% versus 18%), moderately high (10% versus 19%), and highest (12% versus 22%)]. We found that mammography use is less for older black women as compared with white women. For both, greater mammography use is associated with increasing number of primary care visits. However, the deficit for black women persists at each income level even after use of primary care is taken into account suggesting that primary care visits do less to boost mammography use for black than white women.[36]

What remains unknown is whether differential mammography use between black and white women is responsible in part for their differences in breast cancer outcomes.

Black-White Differences in Stage at Diagnosis

The black-white difference in stage of breast cancer diagnosis is well established.[6,14,15,16,17] Prior research has examined factors such as age, lower SES, lower educational level, being unmarried, and receiving medical care from a public hospital setting to help explain the black-white difference in stage at diagnosis.[13,14,15,17] Studies have shown that such differences in stage at diagnosis are greatest when there are greater discrepancies in income between black and white women.[17,21,39] Wells and Horm used breast cancer cases

identified through the SEER Program to evaluate the association between breast cancer stage and race within strata defined by income and within education.[17] They classified women as to SES using 1980 census information on median household income and percent of adults with a high school education according to census tract. They found the proportion of women diagnosed with late-staged disease decreased as income or education levels increased. Wells and Horm also found that black women with lower income or lower education were more likely to be diagnosed with late-stage disease than white women of lower income or lower education. However, the white advantage disappeared among women in upper income ($25,000+) or education (13+ years) strata.[17]

Farley and Flannery studied the relationship between stage and SES among women diagnosed with breast cancer using data from the Connecticut Tumor Registry for the period 1984 and 1985. They used 1980 Census information to group women as low, middle and high SES based on the percentage of adults in their census tract who completed high school. Their results show that black women, compared to white women, were less likely to be diagnosed with in situ disease and more likely to be diagnosed with regional and distant disease. Women of lower SES were also more frequently diagnosed with regional and distant disease when compared to women of higher SES. Among lower SES women, blacks were more likely than whites to

be diagnosed with regional (40% versus 33%) and distant disease (13% versus 9%).[13]

Mandelblatt et al studied the individual and collective effects of age, race, SES and type of health care setting on stage at diagnosis.[15] Her study included all breast and cervical cancer cases diagnosed from 1980 to 1985 and reported to the New York State Department of Health Tumor Registry. SES was measured using 1980 census information on median household income and percentage of adults with a high school education. Results from this study support those of Farley and Flannery even after multivariable logistic regression was used to adjust for other factors related to late-stage at diagnosis. They found that black race was independently associated with late-stage disease after controlling for post-menopausal age, low education, and public hospital use.[15] Although the authors considered low income to be "weakly associated" ($p=0.055$) with late-stage disease in this multivariable model, it is likely that low education and low income within a census tract are highly correlated and are measuring the same social context.

Satariano et al. studied the phenomenon which has been termed *"double jeopardy"*[40] or the health disadvantage of being both elderly and black.[14] This study examined whether the excess risk for advanced breast cancer for black women increased with advancing age. The study population consisted of newly diagnosed breast cancer cases from the SEER Tumor

Registry in Detroit from 1973-1982. They found that the age specific incidence rates for localized and regional disease were higher for white women. On the other hand, black women had higher rates of distant disease. They also found that for both black and white women the proportion of cases diagnosed with regional or distant staged disease increased with older age at diagnosis. These results indicate that older women are at greater risk of being diagnosed with late-stage breast cancer, and that older black women are at particularly high risk of being diagnosed with the most advanced stage of cancer.[14]

To date, the most comprehensive investigation of black-white differences in stage at diagnosis has been conducted by the NCI's Black/White Cancer Survival Study (BWCSS) Group.[41] This study was the first to investigate whether differences in stage at diagnosis between black and white women are due to differential use of preventative health care prior to diagnosis. This study examined the importance of multiple explanatory factors, including preventative health behavior, in explaining the association between black race and stage at diagnosis in newly diagnosed women with breast cancer from Atlanta, New Orleans and San Francisco-Oakland during 1985 and 1986. They found that risk factors were differentially distributed in blacks and whites. Among black women, lack of mammography use in the six years prior to diagnosis, indicators of access to health care, and increased body mass

index were independently associated with advanced stage at diagnosis. Among white women, however, lower income was the only factor associated with advanced stage and this association was weak (p=0.06).[41] These results suggest that lack of preventative health care among black women may explain in part black-white differences in stage at diagnosis.

A recent study by Jones et al., investigated whether black-white differences in stage at diagnosis could be explained by history of screening mammography.[42] This population-based study included black and white women diagnosed with breast cancer who were less than 79 years seen at 22 Connecticut hospitals between 1987 and 1989. Women were asked to report the number of screening mammograms they had during the three years prior to their breast cancer diagnosis or development of symptoms. They found that white women were more likely than black women to have ever had a mammogram (OR=2.34, 95% CI 1.43-3.83) and that white women were two times more likely to have a history of screening mammography during the three years before diagnosis (OR=2.05, 95% CI 1.26-3.35). In contrast to the findings from the BWCSS, a prior history of mammography use was associated with early stage disease *only* among white women. In multivariable analysis, black women were more likely to be diagnosed with late stage disease even after adjusting for history of screening mammography. The authors found that less than 10%

of the observed black-white difference in stage at diagnosis could be accounted for by screening mammography.[42]

Discrepancies between the results of the BWCSS and the Connecticut study leave unanswered whether or not differential use of prior mammography can explain differences in stage at diagnosis between black and white women.

Black-White Differences in Survival

Black-white differences in survival from breast cancer are well documented.[19,20,43] Black women with breast cancer experience a poorer survival as compared with white women. Black-white survival differences have been observed for 1-year, 3-year and 5-year relative survival estimates.[19,21,44] The differences persist even after adjusting for stage at diagnosis.[19,21,44] According to SEER data from 1983 to 1990, the stage-specific 5-year relative survival for black and white women with breast cancer age 50 and older are: localized (89% and 96%), regional (62% and 75%), distant (11% and 18%), and unstaged (42% and 52%).[6]

It is unclear why these black-white differences in survival occur among women with breast cancer. However, prior studies suggest that the survival differences are not entirely due to the fact that black women are more frequently diagnosed with advanced stage disease.[19,20,44] A number of studies have investigated whether other factors including SES, tumor characteristics, access to medical care, and initial treatment

modality help explain the black-white differences in survival.[19,20,43,44]

A study conducted by Dayal et al. examined the role of SES in explaining the poorer survival experience of black women after age and stage at diagnosis were taken into account.[43] This study consisted of women diagnosed with breast cancer from 1968 to 1977 from the Virginia Commonwealth University Tumor Registry. A SES index was computed for each women based on information from her Census tract of residence. They found that black women had poorer survival than white women after adjusting for age and stage at diagnosis. However, once they adjusted for the woman's SES, the survival disadvantage for black women disappeared.

In 1988, Polednak compared the survival experience of black and white women diagnosed with breast cancer in Upstate New York to determine if survival differences persist in a relatively socioeconomically homogenous population.[21] He found that overall survival for black women was lower at 1 and 3-years following diagnosis. He also found that within each stage at diagnosis, survival differences between blacks and whites were small; this was especially true among those diagnosed with localized disease where the survival for black and white women was nearly identical. Results from this study suggest that black-white differences in survival may be small among women of similar socioeconomic status once stage at diagnosis is taken into account.[21]

Other studies have assessed whether differential delay in obtaining treatment contributes to black-white differences in survival.[45,46,47] Treatment delay can be divided into two components: patient delay and system delay. Patient delay is defined as the time interval from when the patient first notices symptoms to their first medical visit; system (or doctor) delay is the interval from the first medical visit until a diagnosis is established (or treatment is administered). Dennis et al. evaluated the association between patient and doctor delay in treatment of breast cancer and survival. Overall, they observed slightly longer intervals of doctor delay in black women, especially in younger black women, but no differences in patient delay were observed between black and white women. They found no correlation between doctor or patient delay and survival.[45] Gregorio et al. evaluated whether survival differences between black and white women were due to patient delay in obtaining treatment. They found no statistically significant differences between black and white women in patient delay. However, they observed a tendency toward longer delays for black women. In multivariable analyses, race was not a significant predictor of survival after controlling for delay, age and stage at diagnosis.[46] A recent study by Caplan et al. examined the role of system delay in black-white differences in survival using data from the BWCSS.[47] Results from this study also demonstrate that black women had slightly longer

median system delay than white women (2.7 versus 2.4 weeks, respectively), although statistical significance was not achieved. In contrast to the findings from Dennis's study, older black women experienced longer system delay than older white women, although younger blacks had shorter system delay than younger whites. These results suggest that the survival disadvantage for black women is unlikely to be due to differences in system delay since the median delay for both racial groups was less than 3 weeks.[47] This study did show, however, that white women were twice as likely to be asymptomatic at presentation. This is consistent with the notion that black women are less likely to be screened for breast cancer and that differential screening may partially explain the poorer survival of black women.[47]

Diehr et al. investigated whether black and white women received different patterns of care after diagnosis of breast cancer.[48] The NCI convened an expert panel of oncologists and surgeons to define patterns of care according to recommended practices. Black and white women were compared according to ten patterns of care. They found that black and white women differed significantly on four patterns of care. In each instance, black women were considered to have received less appropriate care. After adjusting for important factors related to care, black women still received less appropriate care in three of the four patterns of care.[48] This study

provides evidence of differential treatment in black and white women diagnosed with breast cancer.

Other studies have evaluated whether black-white differences in breast cancer treatment are responsible for poorer survival in black women.[20,44,48,49,50] Bain et al. studied black and white women with incident breast cancer from the SEER Tumor Registry in metropolitan Atlanta over the period 1978 to 1982 to determine the effect of black race on survival after adjusting for age, SES (as indicated by county of residence), stage at diagnosis and type of treatment.[20] In multivariable analysis, black women continued to experience significantly worse survival as compared with white women, even after controlling for age, tumor characteristics, and treatment modality. Women from the lower SES county experienced significantly worse survival than women from higher SES counties on bivariate analysis. This association did not persist after adjusting for other prognostic factors, however. They also found that when stratified by stage at diagnosis, black and white women with early-stage disease had similar survival. However among women with advanced disease, black women had significantly decreased survival as compared with white women. This could, in part, be explained by type of treatment received. Among women diagnosed with advanced stage breast cancer, black women were significantly more likely to have had no surgical intervention as compared with white women (30% versus 18%, respectively). However,

treatment for blacks and whites with early-stage disease was similar.[20]

McWhorter and Mayer used SEER data from 1978 to 1982 to evaluate whether type of initial breast cancer treatment differed for black and white women and whether treatment differences explained the racial difference in survival.[44] Women were classified into three treatment categories: surgical, non-surgical and untreated. Results from this study demonstrate that black women were significantly less likely to receive surgical intervention as compared with white women, and more likely to be untreated after adjusting for age, stage at diagnosis and tumor histology. In logistic regression analyses, black women were 40% more likely to die within five years of diagnosis as compared with white women even after controlling for type of treatment, age, stage and tumor histology (adjusted OR for black race=1.4, 95% CI 1.2-1.7).[44] These results suggest that treatment differences do not completely explain the poorer survival among black women, even though they received less aggressive treatment and were more likely to go untreated when compared with white women.

Another study by Kimmick et al. evaluated the race-survival association in a subset of women who were diagnosed with metastatic breast cancer who received the same treatment protocols.[50] This study included all black women on five treatment protocols. Black women were matched to randomly selected white women from the same treatment protocol. They

found that the median survival time for black women was significantly lower than white women (14 months versus 20 months) after adjusting for pretreatment characteristics despite the fact that they received the same treatment regimen. These results suggest that black-white differences in survival among women with advanced stage disease are not explained by treatment alone.[50]

A recent report from the Black/White Cancer Survival Study (BWCSS) examined the role of multiple prognostic factors in explaining observed differences in survival between black and white women.[19] These prognostic factors were sociodemographic characteristics (age at diagnosis, marital status, median income of residence), tumor characteristics at diagnosis (stage, tumor size, number of positive nodes, pathologic grade, histologic subtype), number of comorbid illnesses, and initial method of treatment. The authors found that although these factors contribute to the observed black-white differences in survival, they do not completely explain them. Overall, these factors explained approximately 75% of the survival difference between blacks and whites. They further found that 40% of the difference in survival was explained by more advanced stage of disease among blacks, while 18% of the difference in survival was explained by comorbid illness and sociodemographic factors. The authors concluded that reducing the survival disadvantage for black

women with breast cancer is most likely to be achieved through strategies aimed at early recognition of the disease.[19]

In summary, the survival disadvantage for black women remains partially unexplained; whether or not differences in prior mammography use can account for some of the survival difference between black and white women in unknown.

Limitations of Previous Studies

Previous studies have not taken into account mammography use prior to breast cancer diagnosis when investigating black-white differences in survival. While only two studies have been able to account for mammography use prior to diagnosis when investigating black-white differences in stage at diagnosis,[41,42] and these studies have produced conflicting results. Indeed, information that links prior mammography use, breast cancer diagnosis and breast cancer outcomes for a single population has not previously been available.

Administrative Data

Administrative (claims) databases are frequently used in epidemiologic and health services research.[51,52] Claims databases have been previously used to investigate variations in the incidence, diagnosis and treatment of breast cancer.[53,54,55,56,57] Most recently, Medicare physicians' claims data have been used to study mammography utilization among women on Medicare.[29,36,37,38]

Medicare claims databases offer several advantages for outcomes research.[51] Since the Medicare Program maintains utilization records for each beneficiary from their date of eligibility until their date of death, the data enable researchers to link relevant use of health services longitudinally to construct patterns of care and to relate them to outcomes. These databases are population-based, relatively inexpensive to acquire, they can include large numbers of cases and can be used for long-term follow-up. The limitations of claims databases include missing or incomplete claims data, incomplete or inaccurately coded diagnoses, lack of individual-level socioeconomic data, and lack of information on other potential covariates, such as breast cancer treatment.[51]

Issues In Measuring Mammography Utilization

Prior mammography utilization will be measured using HCFA's Physicians' claims file. There are two major concerns about using claims data to measure prior mammography use. First, the ability to capture all mammograms performed; second, the ability to distinguish diagnostic from screening mammograms (i.e., exams performed on asymptomatic women).

This study may underestimate mammography use because only mammograms paid for by Medicare are captured. Some women could have received screening mammograms that were not billed to HCFA. However, mammography rates from our prior studies

suggest that these data capture the majority of mammograms performed during 1990.[36,38] We found that 15% of women age 65 and older had a HCFA-billed mammogram during 1990.[36,38] This is similar to the percentage found in the 1987 NHIS for women age 65 and older who reported having a mammogram in the last year (14%), although less than the rate found in the 1990 survey (28%)[34] or the reported rate (22%) in the 1990 MAUS survey.[27]

Although, HCFA's reimbursement policy was ostensibly limited to diagnostic bilateral mammograms prior to 1991, one reimbursement criterion allowed physicians to perform mammograms on asymptomatic women.[58] Thus, although these data capture much screening activity, mammograms performed for diagnostic purposes cannot be readily distinguished from screening exams. The NHIS found that 13% of all mammograms performed in a year among women aged 65 years or older, were for "health problems", and that these rates were similar for black and white women (personal communication, NCI, Nancy Breen, Ph.D., January 1995). Furthermore, two recent studies which used Medicare physicians' claims database for the years 1991, 1992, and 1993 (when HCFA was officially reimbursing for screening mammography) found that the CPT coding still did not reliably discriminate between screening and diagnostic studies; a substantial majority of mammograms performed for screening purposes had been billed under the diagnostic code.[29,35]

Linked Medicare-Tumor Registry Database

The Linked Medicare-Tumor Registry Database was jointly created by NCI and HCFA to enable researchers to conduct cancer-related health services research in order to develop an improved understanding of national patterns of costs, utilization, and medical outcomes of cancer prevention and treatment services.[1] The linked database contains records on cancer patients from NCI's SEER Program linked with claims data from HCFA's Medicare Statistical System (MSS) for the years 1985 to 1993.

NCI's Surveillance, Epidemiology, and End Results Program (SEER) is an epidemiologic surveillance system developed in 1973 to track cancer incidence and survival in the United States. SEER contains nine population-based tumor registries that represent approximately 10% of the total U.S. population. Cases are identified by reviewing pathology reports and discharge diagnoses. SEER tumor registries routinely collect information on all cancer patients who live in geographically defined areas and conduct active follow-up for all cases to ascertain mortality. These data are routinely checked for accuracy and completeness; approximately 99% of cancers occurring in the nine registries are identified.[59]

HCFA's Medicare Program provides health insurance coverage for persons age 65 and older, persons under age 65 entitled due to disability and most people with end-stage renal disease. Approximately 97% of the population age 65 and

older are covered by Medicare.[60] Medicare Part A provides coverage for inpatient care in hospitals, skilled nursing facilities, home health care and hospices. Medicare Part B covers services rendered by physicians and other medical providers, and outpatient services (including hospital outpatient, ambulatory surgical centers, and rural clinics). HCFA created a 100% physicians' claims (Medicare Part B) file for the years 1985 to 1990 for ten states. These data were edited to remove all duplicate, reprocessed, and denied claims. Physicians' claims data are available for three geographic areas included in the SEER Program: Connecticut, metropolitan Atlanta, and Seattle.

The linked database contains clinical and medical outcomes information from SEER tumor registries and Medicare claims information regarding inpatient and outpatient cost and utilization. The match rates for Connecticut, Atlanta and Seattle are 93.3%, 94.1% and 91.5%, respectively.[1]

The linked database has been previously used to study the ability of a cancer prevention test (prostate-specific antigen) to influence cancer outcomes (prostate cancer incidence rate).[61] Mammography is a screening test which can be readily identified through claims data and related to documented cancer outcomes. The linked database, therefore, offers a promising methodology for determining whether differential use of prior mammography in older black and white

women helps to explain differences in breast cancer stage at diagnosis and survival.

CHAPTER II

METHODOLOGY

Data Source: Linked Medicare-Tumor Registry Database

A retrospective cohort study was conducted using the Linked Medicare-Tumor Registry Database. The linked database includes five data sources which were used in this study. These data sourceds are described below.

1) The SEER file (1985-1993) provides information on cancer site, stage and tumor size at diagnosis, histological type, initial treatment and follow-up information on survival and cause of death.
2) The Denominator file (1985-1990) is a 100% Medicare beneficiary file that provides sociodemographic information (age, race, zip code and state of residence), dates of Medicare Part A and Part B coverage, reason for entitlement, and date of death for each Medicare beneficiary.
3) The Physicians' Claims file (1985-1990) is a 100% Medicare utilization file with one record for every physician claim covered by Medicare Part B. Each bill lists the procedure code for the service

provided according to the Physicians' Current Procedural Terminology (CPT)[62] coding as well as the specialty of the physician who provided the service.

4) The Medical Provider Analysis and Review (MEDPAR) file (1985-1990) is a 100% Medicare utilization file with one record for every inpatient hospitalization and skilled nursing facility stay covered by Medicare Part A. Each Part A bill contains up to five diagnosis and three procedure codes defined according to the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM).[63]

5) The 1990 U.S. Census data are included in the linked database according to the woman's zip code of residence as an indicator of a woman's socioeconomic status. Census data at the census tract level are available for those areas which lack information at the zip code level. The available indicators are: median household income, percentage of adults with less than a high school education, and percentage in blue collar occupations. Individual socioeconomic information is not available from SEER or Medicare data.

Study Sample

The study sample consisted of women with breast cancer identified from the Medicare - Tumor Registry linked database. Women were eligible for the study sample if they were diagnosed with breast cancer (ICD-9-CM Diagnosis Codes 174-174.9, 198.81, 233.0) between January 1, 1987 and December 31, 1989, aged 67 years and older, of black or white race, and resided in one of the following SEER registry areas: Connecticut, Atlanta, Georgia or Seattle, Washington. Although these areas were selected because physicians' claims are available for all cases, they also represent a geographically diverse population of elderly women with breast cancer. The final study sample was limited to women aged 67 years and older to ensure that all women had a minimum of two years of Medicare utilization (claims) information prior to their diagnosis.

Women with a prior history of cancer were excluded from this study. Women enrolled in an HMO and women with less than one full year of Medicare coverage were also excluded, since physician claims data, which are required for identifying mammography use prior to breast cancer diagnosis, are missing or incomplete.

Measure of Mammography Utilization

Physicians' claims data were used to identify women who had a bilateral mammogram(s) (CPT procedure code 76091) and the date each was performed. This information was used to classify women into the following categories of mammography use: 1) Nonusers, 2) Regular Users, 3) Peri-diagnosis Users, and 4) Uncertain. Women were classified as: 1) *Nonusers* if they did not have any mammograms during the entire two year period prior to their diagnosis, 2) *Regular Users* if they had at least two mammograms in the two years prior to their breast cancer diagnosis that were ten or more months apart, and 3) *Peri-diagnosis Users* if they had their only mammogram(s) within three months prior to their diagnosis. Women who did not fit into any category listed above were classified as *Uncertain* (6.6%) and excluded from the analysis. "Peri-diagnosis users" are a heterogeneous group of women whose only mammography use was close to their date of diagnosis. This group includes women who had a screening mammogram and were diagnosed with breast cancer and those who had a diagnostic mammogram. Therefore, analyses relating prior mammography use to breast cancer outcomes were limited to nonusers and regular users as they are two distinct groups of women.

Outcome Variables

The outcome variables for this study were stage at diagnosis, all-cause mortality, and stage-specific mortality.

Stage at Diagnosis

SEER records breast cancer stage at diagnosis using two classification systems. The first is the historical staging system (in situ, localized, regional, distant or unstaged) which SEER has used since its inception. In 1988, SEER began using the more specific modified TNM staging system established by the American Joint Committee on Cancer.[64] The TNM staging system classifies tumors according to size (T), absence or presence of nodes (N) and absence or presence of distant metastases (M). Cases diagnosed in 1987 are only classified according to the historical staging system whereas those diagnosed from 1988 to 1989 are classified according to both systems. Although the TNM staging system is more precise, the historical system is sensitive enough to distinguish differences in survival.[14]

Therefore, stage at diagnosis was analyzed using the historical staging system in order to take advantage of all three years of data. Stage was defined as *early-stage* (in situ/local) *versus late-stage* (regional/distant) disease. This distinction was made because 5-year survival rates decrease markedly for women with localized as opposed to

regional and distant disease.[5] Unstaged cases (3.2%) were excluded from all analyses.

Survival

Survival time was measured from date of diagnosis until date of death, date of last known follow-up contact or the end of the follow-up period (December 31, 1993). Date of diagnosis in SEER data is limited to year and month, therefore, all cases were arbitrarily assigned to the *15th* day. The follow-up period ranged from a minimum of 4 years to a maximum of 7 years. Survival was analyzed in the following two ways: 1) all-cause mortality, and 2) stage-specific mortality. Women lost to follow-up or who were alive on December 31, 1993 contributed "censored" observations.

Survival analyses included only women with invasive breast cancers (n=1,484). Those with in situ cancers (n=162) were excluded as it is unknown what proportion will progress to invasive disease. Therefore, *early-stage* was defined as local disease and *late-stage* was defined as regional or distant disease in survival analyses.

Explanatory Variables

The explanatory variables available from the linked database are listed below. Potentially associated variables were grouped into the following domains: sociodemographic,

comorbidity and breast cancer characteristics. The data source and categories of each variable are as follows.

Sociodemographic

Age at diagnosis, marital status at diagnosis, race, and SEER area were obtained from the SEER file. Age at diagnosis was analyzed as a continuous variable (range 67-100 years). Marital status was dichotomized as currently married at diagnosis versus not married. Race was dichotomized as black versus white. SEER area was defined according to the SEER tumor registry of diagnosis: Connecticut, Seattle, and Atlanta. Women were assigned the median household income of their zip code of residence and grouped as < $15,000 versus ≥ $15,000 in order to be consistent with other studies that used SEER data.

Comorbidity Information

SEER data lack information on comorbid conditions. Therefore, diagnostic codes from MEDPAR data were used to estimate a comorbidity score for women who had been hospitalized. The number of inpatient hospitalizations were counted for each women beginning two years prior to diagnosis and ending one month after diagnosis. A decision was made a priori to extend the period of observation to one month past diagnosis because it was expected that the majority of women would have at least one hospitalization around their breast

cancer diagnosis; this is likely to be true because during this study period (1987 to 1989) most women received their initial cancer treatment as an inpatient. Next, a modified Charlson Comorbidity Index was computed using Deyo's method[65] of classifying ICD-9-CM diagnosis codes from all inpatient hospitalizations combined. The comorbidity score used in this study is an ordinal variable (range 0-2). Non-hospitalized women were assigned a comorbidity score of 0 because their comorbidity could not be assessed. Women who were hospitalized, but had no comorbid conditions (i.e., a Charlson Index of 0) were assigned a comorbidity score of 1. Women with a Charlson Index of 1 or greater were assigned a comorbidity score of 2.

Breast Cancer Characteristics

SEER provided information on histologic subtype and pathologic grade of the tumor. Histologic subtype was dichotomized as infiltrating ductal, not otherwise specified versus other and unknown subtypes. Pathologic grade was categorized as well or moderately differentiated versus poorly differentiated and unknown. Treatment modality was recorded as the initial type of site-specific surgery (including whether an axillary lymph node dissection was performed or not), whether radiation was performed or not, and the radiation to surgery sequence. Initial treatment modality was

categorized as no radiation or surgery, radiation only, surgery only, and radiation plus surgery.

Statistical Analysis

Analyses were performed to describe the study sample. Black and white women were compared on the sociodemographic, comorbidity and breast cancer characteristics identified above. The chi-square statistic was used to identify characteristics that differed significantly between black and white women.

Analyses which addressed each of the study objectives are described below. All statistical analyses were conducted using SAS statistical software version 6.11.[66]

Describe Factors Associated with Prior Mammography Use

Objective 1

Bivariate analyses were performed to explore factors associated with mammography use in elderly women prior to their breast cancer diagnosis. These factors included age at diagnosis, race, marital status, income, SEER area, and comorbidity score. The chi-square statistic was used to identify factors significantly associated with prior mammography use. Analyses within race strata were done to examine whether associations with prior mammography use are similar for black and white women.

Relate Prior Mammography Use to Stage at Diagnosis

Objective 2

Chi-squared tests were used to examine the relationship between prior mammography use and stage at diagnosis for all women. Analyses were repeated within race strata to determine if the relationship between prior mammography use and stage at diagnosis is similar for black and white women. Finally, analyses were repeated among nonusers and regular users to determine if the race-stage association persists within strata of prior mammography use.

Relate Prior Mammography Use to Survival

Objective 3

Analyses were performed to determine the association between prior mammography use and each outcome measure of survival (all-cause mortality and stage-specific mortality). The survival function was estimated using the Kaplan-Meier product limit method and plotted against time. Estimated survival curves were plotted on a *log-log scale* {i.e., $\log_e$(-$\log_e$ survival function)} *versus time* to visually inspect the data for gross violations of Cox's assumption of proportionality. Kaplan-Meier survival curves were obtained for nonusers and regular users to determine if prior mammography use was associated with better survival. Race-specific survival curves were obtained to determine if regular use of mammography prior to diagnosis was associated with

better survival for black women as well as white women. Generalized Wilcoxon tests and Cox-Mantel log-rank tests were used to determine the statistical significance of differences between Kaplan-Meier survival curves.

Relate Prior Mammography Use to Black-White Differences in Stage at Diagnosis

Objective 4

Hierarchical logistic regression models were fitted to determine the extent to which the black-white difference in stage at diagnosis is explained by differential use of mammography prior to diagnosis. This analytic technique was used to compare simple models to more complex models. The outcome variable was *late- versus early-stage* disease.

Groups of related potential explanatory factors were formed. These groups were sociodemographic characteristics (excluding race), comorbidity, and prior mammography use. These groups of related factors were added first in turn, and then in a cumulative fashion to the simple model which contained only the race variable. This technique was used to examine the change in the race coeficient caused by each of the individual groups of factors, and to examine the change in the race coefficient caused by adding prior mammography use to a model which contained all of the available explanatory factors.

A simple model was fitted to predict late-stage disease from race *(black versus white)*. This simple model provided a crude estimate of the odds ratio (OR) for the association between black race and late-stage disease. Next, two series of more complex models were fitted. The estimated crude OR for race was then compared with those obtained from the more complex models that adjusted the race-stage association for other predictors of stage.

For each model, the OR for blacks compared with whites and 95% confidence interval (CI) were computed from the estimated beta coefficient and its standard error. The Wald statistic was used to assess the statistical significance of the race coefficient from successively more complex models.[67]

The first series of logistic models were fitted to estimate the race-stage association after adjusting for individual groups of related factors. The models in this series were:

1) race + sociodemographic characteristics,

2) race + comorbidity score, and

3) race + prior mammography use *(nonuser versus regular user)*.

The adjusted OR for race obtained from each of these models was compared with the crude OR for black race using a *"change-in estimate"*[68] approach. This approach quantifies the extent to which the black-white difference in stage at diagnosis is explained by the individual groups of related factors.

The second series of logistic models were fitted to examine the extent to which the black-white difference in stage at diagnosis is explained by adding prior mammography use to a model which includes all other available factors. This was accomplished by fitting two models:

1) race + sociodemographic characteristics + comorbidity score, and

2) race + sociodemographic characteristics + comorbidity score + prior mammography use.

The comparison of the ORs for black race between these two models indicates the additional amount of the black-white difference in stage at diagnosis that is explained by prior mammography utilization after the other factors have been considered.

Relate Prior Mammography Use to Black-White Differences in Survival

Objective 5

A similar analytic methodology was applied to determine how much of the excess mortality among blacks could be explained by differences in prior mammography use. Hierarchical multivariable models were fitted using the Cox stratified proportional hazards regression method[69] and changes in the estimated race coefficient were assessed.[68] Models were stratified on SEER area as the assumption of proportional hazards was not met by this variable. Analyses

were preformed for all-cause mortality and stage-specific mortality. In analyses of stage-specific mortality, models were fitted separately for early- and late-stage disease.

Using a methodology similar to that used in the stage analysis, groups of related potential prognostic factors were formed. These groups were sociodemographic characteristics (excluding race), comorbidity, stage at diagnosis, and prior mammography use. Again, groups of prognostic factors were added first in turn, and then in a cumulative fashion to the simple model which contained only the race variable. This approach was used to examine the change in the race coeficient caused by each of the individual groups of factors, and to examine the change in the race coefficient caused by adding prior mammography use to a model which contained all of the available prognostic factors.

Hierarchical Cox stratified proportional hazards models were fitted to estimate the risk of death for black women as compared to white women. The estimated relative risk of mortality (RR) (i.e., hazard ratio) for race and the corresponding 95% confidence intervals (CI) were computed and the Wald statistic was used to determine the statistical significance of the race coefficient.

First, a simple model was fitted to predict mortality from race *(black versus white)*. The crude RR obtained from this model represents the relative risk of mortality estimated for black women relative to white women. Next, two series of

more complex models were fitted. The estimated crude RR was compared with subsequent, more complex models to determine the impact on the race coefficient of adding important groups of related prognostic factors.

The first series of models were fitted to determine the effect on the race-mortality association of adding individual groups of factors to the simple model. The models were:

1) race + sociodemographic characteristics,
2) race + comorbidity score,
3) race + stage at diagnosis, and
4) race + prior mammography use *(nonuser versus regular user)*.

The estimated crude RR was compared to the adjusted RR from each model to determine the extent to which the black-white difference in survival was explained by the individual groups of factors.

The second series of models were fitted to determine the incremental effect of prior mammography use in explaining the black-white difference in survival. The first of two models in this series included the variable for race and all of the available prognostic factors (sociodemographic characteristics, comorbidity score, and stage at diagnosis). The second model included race, the available prognostic factors, and prior mammography use. The race coefficients and estimated RRs from these two models were compared. This analysis provided information about the additional ability of

knowledge of prior mammography use to explain the black-white difference in survival. The Wald statistic for prior mammography use in the latter model was used to test whether prior mammography use was independently predictive of survival after adjusting for the important prognostic factors previously reported in the literature.

CHAPTER III

RESULTS

The characteristics of the study sample (n=4,005) are presented in Table 1. Overall, 4% (n=172) of the women were black, 48% resided in Connecticut, 35% resided in Seattle, and 17% in Atlanta. Nearly half (49%) of the women were aged 67 to 74 years at the time of their breast cancer diagnosis, 41% were aged 75 to 84 years, and 10% were aged 85 years or older. Thirty-seven percent of the women were married, and 16% resided in a low income area (i.e., a zip code area with a median income of less than $15,000).

A comorbidity score could only be estimated for women who were hospitalized within two years prior to their diagnosis and/or within one month after their diagnosis. Overall, 19% of the women were not hospitalized, 59% of the women had a comorbidity score of 0 (i.e., no comorbid conditions), and 22% of the women had a comorbidity score of 1 or greater (i.e., at least one comorbid condition).

Mammography utilization was examined for each woman during the two year period preceding her breast cancer diagnosis. Twenty-two percent of the women did not have any mammograms during the two years prior to their breast cancer

diagnosis (nonusers), 19% the of women had at least two mammograms during the two years preceding diagnosis that were ten or more months apart (regular users), and 59% of the women had their only mammogram(s) within three months prior to their diagnosis (peri-diagnosis users). Overall, one-third (32%) of the women were diagnosed with late-stage disease.

Racial comparisons of these characteristics are also presented in Table 1. Black-white differences were apparent across the three SEER areas: more black women than white women resided in Atlanta (66% versus 15%) and fewer black women resided in Connecticut (25% versus 49%) or Seattle (9% versus 36%). Black women were less likely to be married (18% versus 38%) and more likely to live in a low income area (75% versus 13%). Comorbidity score also varied with race: black women were more likely to have no hospitalizations (27% versus 19%) and to have at least one comorbid condition (27% versus 21%) as compared with white women. There was no black-white difference in age at diagnosis.

Prior mammography use differed between black and white women. Black women were over-represented among nonusers of mammography (35% versus 22%) and under-represented among regular users of mammography (11% versus 19%). However, the percentages of black and white peri-diagnosis users of mammography were similar (56% versus 59%). Factors associated with prior mammography use are found in Appendix Table A-1.

Stage at diagnosis also differed between black and white women. Black women were more often diagnosed with late-stage disease as compared with white women (39% versus 32%).

Stage at Diagnosis

Bivariate associations with late-stage disease among nonusers and regular users of mammography (n=1,646) are presented in Table 2. Black women were significantly more likely to be diagnosed with late-stage disease as compared with white women (OR=2.49, 95% CI 1.59-3.92). Women who resided in Connecticut or Atlanta were more likely to be diagnosed with late-stage disease than those who resided in Seattle. Women who had no comorbidities and women who had at least one comorbidity were more likely to be diagnosed with late-stage disease when compared with women who were not hospitalized. A weak positive association with late-stage at diagnosis was observed among women who resided in a low income area (OR=1.32, 95% CI 1.01-1.73). No important differences were observed in stage at diagnosis by age at diagnosis or marital status.

Prior mammography use was strongly associated with late-stage disease at diagnosis. Nonusers of mammography were significantly more likely to be diagnosed with late-stage disease as compared with regular users (OR=3.00, 95% CI 2.41-3.75).

The crude odds ratios for late-stage disease comparing nonusers with regular users of mammography are presented separately for black and white women in Table 3. These analyses were performed to determine whether prior mammography use is important in black women and in white women. Prior mammography use was strongly associated with stage at diagnosis in both blacks and whites. Among black women, the odds of being diagnosed with late-stage disease was 6.65 comparing nonusers to regular users (95% CI 1.96-22.53). Among white women, the odds of being diagnosed with late-stage disease was 2.83 comparing nonusers to regular users (95% CI 2.25-3.56).

The crude and adjusted odds ratios for late-stage disease, comparing black with white women by prior mammography use, are shown in Table 4. These analyses were performed to determine whether race is related to late-stage disease after considering prior mammography use. Among nonusers, black women were significantly more likely to be diagnosed with late-stage disease as compared with white women [crude OR=2.46, 95% CI 1.43-4.22). After adjusting for SEER area, age, marital status, income, and comorbidity, the odds of late-stage disease was still higher among black women (adjusted OR=2.54, 95% CI 1.37-4.71). However, among regular users of mammography, black and white women were equally likely to be diagnosed with late-stage disease (adjusted OR=1.34, 95% CI 0.40-4.51).

Results obtained from four logistic regression models are summarized in Table 5. Model 1 is the crude odds ratio for late-stage disease comparing black women with white women. Models 2, 3, and 4 adjust the race-stage association for other important predictors of late-stage disease - sociodemographic characteristics, comorbidity and prior mammography use. Prior mammography use was the strongest single contributor to the observed black-white difference in stage. Prior mammography use by itself explained nearly 30% of the excess late-stage breast cancer in black women relative to white women and reduced the odds ratio for black race from 2.49 (95% CI 1.59-3.92) to 2.05 (95% CI 1.29-3.26).

Hierarchical logistic regression models are presented in Table 6. These results indicate the extent to which prior mammography use can explain the black-white difference in stage at diagnosis after the other factors are taken into account. Model 1 is the crude odds ratio for late-stage disease comparing black women with white women. Model 2, which adjusts for sociodemographic characteristics and comorbidity information, did not result in a significant reduction in the odds ratio for black race. However, additional adjustment for prior mammography use (Model 3) reduced the odds ratio for black race from 2.47 (95% CI 1.48-4.11) to 2.30 (95% CI 1.36-3.88). The comparison of Models 2 and 3 demonstrates that prior mammography use explained

approximately 12% of the excess late-stage breast cancer in black women after adjusting for all of the other factors.

Survival

Bivariate associations with mortality from proportional hazards modeling are presented for the total study sample (n=1,484) and by race in Table 7. These analyses were performed to identify significant predictors of mortality in the entire study sample and to determine if the factors which predict mortality are similar for blacks and whites. Overall, black women experienced a higher risk of death relative to white women (RR=1.52, 95% CI 1.07-2.16). Late-stage disease at diagnosis was strongly associated with mortality such that women who were diagnosed with late-stage disease were three times more likely to die than those with early-stage disease.

Although prior mammography use did not achieve statistical significance among black women, the magnitude of the association was similar to that of white women (RR=2.54 95% CI 0.89-7.23). In the total study sample, prior mammography use was strongly associated with survival. Survival was significantly worse for nonusers than for regular users of mammography as demonstrated in Figure 1 ($p<0.001$). The risk of death for women who were nonusers was three times greater than those who were regular users (RR=3.13 95% CI 2.53-3.85) (Table 7).

Other factors that were significantly associated with mortality in the study sample were older age, being unmarried, residence in Connecticut or Atlanta, being diagnosed in 1989, and having at least one comorbid condition. Among white women (n=1,413), significant predictors of mortality were similar to those found in the total study sample. Among black women (n=68), however, the only factors which were significantly related to mortality were late-stage at diagnosis and having at least one comorbid condition.

Results obtained from selected proportional hazards models are summarized in Table 8. Model 1 is the estimated crude relative risk of death for black women relative to white women. Models 2 and 3 adjust the race-mortality association for prior mammography use and stage at diagnosis, respectively. Models which adjust the race-mortality association for sociodemographic characteristics and comorbidity alone had little effect on the relative risk for black race and therefore, are not presented here. However, these results can be found in Appendix Table A-2 as a part of the complete list of proportional hazards models examined in this analysis.

Stage at diagnosis was the strongest single contributor to the observed black-white difference in survival reducing the estimated relative risk for black race from 1.52 to 1.06 (95% CI 0.73-1.55) such that black women continued to demonstrate a slightly increased, but not significant, risk of

death. Prior mammography use produced the second greatest change the estimated relative risk for black race. Prior mammography use by itself reduced the estimated relative risk for black race from 1.52 to 1.27 (95% CI 0.88-1.84). Model 4 presents the estimated relative risk for black race adjusting for stage at diagnosis and prior mammography use. The result generated from this model when compared to the model with stage alone (Model 3) demonstrate that prior mammography use further reduced the estimated relative risk for black race from 1.06 to 0.99 (95% CI 0.68-1.45). Finally, Model 5 presents the estimated relative risk for black race from a full model which adjusted the race-mortality association for all available prognostic factors (adjusted RR=0.96 95% CI 0.64-1.43). Note that the addition of sociodemographic characteristics and comorbidity had little impact on race when compared to the model with stage and prior mammography use (Model 4). However, prior mammography use was a significant prognostic factor even after considering stage at diagnosis in Models 4 and 5 (data not shown).

Since prior mammography use is hypothesized to work through stage of diagnosis by identifying tumors earlier in the disease process, we expected that prior mammography use would have no additional explanatory power once stage was included in the survival model. To further explore this counter-intuitive finding, analyses were preformed to examine the association between prior mammography use and survival

within stage at diagnosis. The stage-specific Kaplan-Meier survival curves are presented in Figures 2 and 3. These findings demonstrate that nonusers of mammography had a worse survival experience than regular users that is independent of stage at diagnosis.

The results of the stage-specific multivariable analyses are presented in Table 9. Among women diagnosed with early-stage disease, the adjusted risk of death for nonusers was significantly higher than regular users of mammography (adjusted RR=1.76 95% CI 1.30-2.41). Similar, yet a slightly stronger association was observed among women diagnosed with late-stage disease in that nonusers were significantly more likely to die than regular users of mammography (adjusted RR=2.25 95% CI 1.59-3.17).

CHAPTER IV

CONCLUSION

This study examined the relationship between prior mammography use and cancer outcomes in older black and white women diagnosed with breast cancer. Similar to previous results,[29,34,35,36,37,38] older black women were less likely to undergo regular mammography than older white women in this study. This study also confirmed the black-white difference in stage at diagnosis[6,14,15,16,17] and survival[19,20,21,43,44] observed in previous studies. Older black women were diagnosed at later stages of breast cancer and they experienced a higher risk of death as compared with older white women. The objective of this dissertation research was not to simply document differences between older black and white women, but to determine the extent to which black-white differences in breast cancer outcomes could be accounted for by differential mammography use prior to their breast cancer diagnosis.

In the present study, mammography use was strongly associated with late-stage disease in both black and white women. This finding differs from those of two previously published studies examining the relationship between mammography use and black-white differences in stage at

diagnosis.[41,42] Hunter et al. found in the Black/White Cancer Surveillance Study that prior mammography use was associated with stage at diagnosis only in black women.[41] In contrast, Jones et al. found an association between prior mammography use and stage at diagnosis only in white women.[42] There are three major differences in the design of these studies which may be partly responsible for these differing results. First, the focus of the present study was on older women. We studied women age 65 years or older and imposed no upper age limit. In contrast, the study samples of Hunter and Jones included women aged 20 to 79 years. Second, mammography use was measured during the two years prior to diagnosis in the present study. Women had to have had at least two mammograms that were at least 10 months a part in order to be considered a regular user. Hunter[41] ascertained a history of screening mammography during the six years preceding diagnosis and Jones[42] ascertained a history of screening mammography during the three years preceding diagnosis. Third, the historical staging system was used as it was available for all women in this study. Hunter and Jones used the more precise TNM staging system in their studies.[41,42]

The results of this study suggest that the black-white difference in breast cancer stage at diagnosis among older women is strongly linked to prior mammography use. Black women who were nonusers of mammography were significantly more likely to be diagnosed with late-stage disease as compared

with white women who where nonusers. However, among women who were regular users of mammography, there was no black-white difference in stage at diagnosis. This finding suggests that older black women benefit from regular mammography use.

In this study, prior mammography use explained much of the variation in stage at diagnosis. Prior mammography use was the strongest single contributor to the black-white difference in stage at diagnosis. In fact, approximately 30% of the excess late-stage breast cancer among black women was explained by prior mammography use alone. In contrast, Jones et al. found that prior mammography use was not an important explanatory factor in their study. The authors found that prior mammography use explained less than 10% of the black-white difference in stage at diagnosis after adjusting for age.[42] Hunter et al. also found that prior mammography use alone did not appreciably alter the race-stage association.[41]

In the present investigation study, individual and combined adjustment for sociodemographic characteristics and comorbidity produced only modest changes in the race-stage association. Thus, these explanatory factors do not adequately explain the excess of late-stage disease among black women. However, prior mammography use explained about 12% of the black-white difference in stage at diagnosis after adjusting for sociodemographic characteristics and comorbidity. These findings suggest that the advanced stage

of breast cancer at diagnosis is partly related to the lack of mammography use by older black women.

Since this study sample consisted of only older women, it is difficult to compare these survival results to those of other published studies that have addressed black-white differences in survival. Furthermore, to our knowledge, this was the first study to examine the extent to which black-white differences in survival could be explained by prior mammography use. Older black women were at a significantly greater risk of death compared with older white women, although the lower 95% confidence bound was only slightly larger than one. The latter may be explained by the small number of black women (n=68) in this analysis. Therefore, the results pertaining to on black-white differences in survival should be interpreted with caution.

Prior mammography was strongly associated with survival in this study sample. Nonusers of mammography were three times more likely to die than regular users of mammography. In stratified analyses, prior mammography use was significantly associated with survival only among white women. Although the magnitude of the point estimate for black women was similar to that observed for white women, it did not achieve statistical significance. A larger number of black women would be necessary to give precision to this estimate.

As expected, stage at diagnosis was the strongest single contributor to the black-white difference in survival.

Adjustment for stage by itself was sufficient to reduce the relative risk for black race, such that there was no longer a significant association with survival. Adjustment for sociodemographic characteristics and comorbidity resulted in only minimal changes to the survival difference between black and white women. These results support the findings of Eley et al. in the Black/White Cancer Surveillance Study.[19] In that study, stage at diagnosis was the single factor that produced the largest reduction in the survival differences between blacks and whites.[19] Furthermore, sociodemographic characteristics, comorbidity, tumor pathology, and treatment did not appreciably alter the relative risk for black race when they were considered individually.[19]

Prior mammography use also contributed significantly to the difference in survival between races. Prior mammography use reduced the relative risk of death for black women as compared with white women from 1.52 (95% CI 1.07-2.16) to 1.24 (95% CI 0.87-1.76). The reduction in risk produced by prior mammography use was second only to stage at diagnosis. Combined adjustment for stage at diagnosis and prior mammography use further reduced the magnitude of the relative risk such that there was no longer any evidence of a survival difference between black and white women. Furthermore, prior mammography use continued to be a significant predictor of survival even after adjusting for stage at diagnosis.

It was notable that prior mammography use was an independent predictor of survival even after stage at diagnosis was accounted for in the model. Stage-specific analyses were conducted to further examine the association between prior mammography and survival. There was a consistent excess risk of death for nonusers of mammography relative to regular users within categories of stage at diagnosis. There are at least five potential explanations for this finding. First, prior mammography use may be a marker for other unmeasured prognostic factors such as access to health care, and use of other preventative services (i.e., clinical breast exam, self breast exam). Second, the SEER historical staging system was used in this study rather than the TNM staging system that classifies tumors based on tumor size, numbers of positive nodes, and metastases. The TNM staging system is a more precise measure of stage at diagnosis. It is possible that prior mammography would not be independently associated with survival if the more specific staging system was used. Because SEER began collecting the modified TNM staging system in 1988, this can be examined in future studies as additional SEER-Medicare linked data become available. Third, recent data from women with ovarian cancer suggests that women with *BRCA1* mutations have a more favorable prognosis than women without *BRCA1* mutations.[79] In this study, it is possible that women with *BRCA1* gene mutations may be more likely to be regular users of mammography and

therefore would have better survival than nonusers of mammography within stage at diagnosis. A fourth potential explanation for this finding is the effect of lead-time bias. Regular users of mammography could be diagnosed earlier within each stage making their survival appear longer, even if early diagnosis in not prolonging their lives. Finally, length-time bias could explain this finding as more frequent mammography may lead to the detection of slower-growing less-aggressive tumors that are less likely to be fatal within a given stage.[71]

Limitations

There are several potential limitations to this study. As discussed in Chapter I, there are limitations to using claims data to measure mammography utilization. For instance, Medicare only began reimbursing providers for screening mammography on January 1, 1991. Prior to the change in reimbursement policy, only diagnostic mammograms were a covered Medicare benefit. Despite this policy, studies have shown that providers were performing screening mammograms and billing Medicare under the diagnostic procedure code.[29,35,36,38] It is possible that physicians providing care to black patients may have been less willing to bill screening mammograms under the diagnostic code. Next, Medicare requires that beneficiaries meet an annual $100 deductible for Part B services and provide a 20% copayment for mammography. This is

a potentially limiting factor in that black and low income women may be less willing or able to pay the deductible and copayment. Previous research has shown that even small "out-of-pocket" costs reduce the use of preventative services.[72] A recent study by Kiefe et al. demonstrated that cost was a major barrier to mammography among low-income minority women despite Medicare coverage.[66] They found that covering "out-of-pocket" costs significantly increased mammography utilization in their population.[66]

Moreover, this study may underestimate actual mammography use among women on Medicare, as some women may have had mammograms that were not billed to and paid for by Medicare. For example, some women may have received mammography through special "free care" intervention programs, such as those sponsored by the American Cancer Society. Others may have received mammograms that were paid for "out-of-pocket". In these instances, a Medicare bill would not be generated and therefore would not be captured by this database. Blustein compared self-reported mammography use to Medicare bills for 1991.[35] She found that mammography rates based on self-report were somewhat higher than rates based on claims data.[35] However, it is unknown how self-reported estimates relate to the "true" screening mammography rate as they may include women who had mammography that was not billed to Medicare as well as those who inaccurately recalled having had a mammogram.

We do not know why an individual mammogram was performed since we cannot determine whether a mammogram was done for screening or diagnostic purposes. To address this issue, we took into account how women used mammography over time during the two years preceding their breast cancer diagnosis. We defined our measure of prior mammography use to identify two distinct groups of women: 1) those who had no evidence of mammography during the two years prior to diagnosis, and 2) those who demonstrated a pattern of regular mammography use. Although diagnostic mammograms represent only a small fraction of all mammograms performed, they are likely to occur shortly before diagnosis in a breast cancer population. Women who had all of their mammograms within three months prior to their diagnosis were excluded from these analyses since we could not determine whether a screening or a diagnostic mammogram was performed.

Nevertheless, a number of recent studies have used Medicare claims data to examine mammography use in the Medicare population.[29,35,36,38] Each of these studies consistently found that black women were less likely to receive mammography than white women.[29,35,36,38]

Furthermore, this study lacks information on factors that may influence mammography use including a family history of breast cancer and an individual's knowledge, attitudes, beliefs and health behavior. However, the most important determinant of mammography utilization is having a primary

care provider.[73,74] In this study, the number of outpatient visits was used as a proxy for access to mammography services. We found that regular mammography use was highly associated with number of outpatient visits. However, the focus of the present investigation was *not* to try to understand the factors that determine who receives regular mammography but to compare breast outcomes among women who used regular mammography with those who did not.

Breast cancer risk factors such as family history, genetic background, and other endogenous factors play a more important role in the development of premenopausal breast cancer, whereas in elderly women, environmental factors and age play a more important role in the development of disease.[7]

Misclassification bias and residual confounding could have occurred through further mechanisms. Proxy information was used to measure co-existing diseases and socioeconomic status, since direct measures were not available. Although a modified Charlson Comorbidity Index was used as a proxy for comorbidity, this score could only be computed on women who were hospitalized. Since comorbidity could not be estimated for non-hospitalized women, non-hospitalized women with comorbid illness were misclassified. However, during this study period women were primarily hospitalized for their breast cancer diagnosis; therefore, we were able to compute a Charlson Index for roughly 81% of the study sample. Furthermore, each woman was assigned to the median income of

her residence using 1990 census data as a proxy for socioeconomic status. This methodology lends itself to potential bias due to an "ecologic fallacy". Specifically, poor women living in wealthy areas might appear to be wealthy and vice versa. However, this methodology has been employed in several breast cancer studies,[13,15,17,43,56] and may capture unknown characteristics that are related to a person's neighborhood of residence, such as access to care or environmental exposures.[15,75] Misclassification and residual confounding of these variables would tend to bias the study results towards no difference making it more difficult to detect a difference if it existed. Any differences found would therefore tend to be conservative.

This study also lacked some prognostic factors related to survival. Estrogen receptor status and use of medications such as tamoxifen were not available in this database. Prior research has shown that estrogen receptor status and breast cancer treatment differs between black and white women.[19] Treatment information was also limited to initial breast cancer treatment and was crudely categorized as radiation only, surgery only, and radiation plus surgery. Eley et al. found that, individually, treatment differences and tumor pathology explained little of the black-white difference in survival.[19] However, stage at diagnosis, which was available in this study, has been consistently shown to be the most important prognostic factor for survival.[19]

Finally, lead-time and length-time biases may also limit the results of this study as discussed above. Stage-specific survival models were fitted to examine survival differences between nonusers and regular users of mammography within stage at diagnosis. Nonusers of mammography experienced significantly worse survival than regular users regardless of stage at diagnosis.

Summary

This study is unique in that it evaluates the relationship of prior mammography use to differences in stage of breast cancer at diagnosis and survival in older black and white women in a single study sample. This study underscores the importance of regular mammograms for all older women. These results suggest that regular mammography use improves breast cancer outcomes in *both* black and white women by identifying tumors at earlier stages of disease.

Furthermore, these results suggest that older black women benefit from regular mammography use to a similar extent as older white women. Black women who are nonusers of mammography are at particularly high odds of being diagnosed with late-stage disease as compared with black regular users. They also suggest that the black-white difference in stage at diagnosis persists among nonusers of mammography but is not present among regular users of mammography. These results further suggest that differences in breast cancer outcomes is

not strongly linked to race, but is rather an issue of whether or not a woman receives regular mammograms.

These findings highlight the need for concerted efforts to improve breast cancer screening in older women. Efforts to promote nationwide breast cancer screening among older women require additional understanding of the relationship between patient, physician, and health care system factors which determine why some women do not receive regular mammography. Interventions should be developed and targeted towards older black women as they are at greater risk of being diagnosed with late-stage breast cancer and dying. Early detection of breast cancer through regular mammography use reduces the survival disadvantage among older black women.

TABLES AND FIGURES

Table 1

Characteristics of the Study Sample (n=4,005) by Race

	White (n=3,833)	Black (n=172)
	n (%)	n (%)
SEER Area***		
Connecticut	1876 (49)	42 (25)
Seattle	1385 (36)	16 (9)
Atlanta	572 (15)	114 (66)
Age at Diagnosis		
67-74	1863 (49)	88 (51)
75-84	1573 (41)	69 (40)
≥ 85	397 (10)	15 (9)
Married at Diagnosis***		
No	2371 (62)	141 (82)
Yes	1462 (38)	31 (18)
Median Income of Zip Code***		
≥ $15,000	3316 (87)	42 (25)
< $15,000	496 (13)	126 (75)
Comorbidity Score**		
No Hospitalizations	711 (19)	46 (27)
0	2287 (60)	79 (46)
≥ 1	835 (21)	47 (27)
Mammography**		
Nonuser	833 (22)	61 (35)
Regular User	733 (19)	19 (11)
Peri-Diagnosis User	2267 (59)	92 (56)
Stage at Diagnosis*		
Early	2622 (68)	105 (61)
Late	1211 (32)	67 (39)

$^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.0001$.

Table 2

Factors Associated with Late-Stage Disease among Mammography Nonusers and Regular Users
(n=1,646)

	n	% Late-Stage Disease	OR (95% CI)
Race***			
White	1566	32	1.00
Black	80	54	2.49 (1.59-3.92)
SEER Area***			
Seattle	543	25	1.00
Connecticut	763	38	1.80 (1.42-2.31)
Atlanta	340	35	1.59 (1.18-2.14)
Age at Diagnosis			
67-74	800	32	1.00
75-84	657	32	1.03 (0.82-1.28)
≥ 85	189	38	1.28 (0.92-1.78)
Married at Diagnosis			
No	1017	34	1.00
Yes	629	32	0.91 (0.74-1.13)
Median Income of Zip Code*			
≥ $15,000	1357	38	1.00
< $15,000	276	32	1.32 (1.01-1.73)
Comorbidity Score***			
No Hospitalizations	338	24	1.00
0	959	33	1.53 (1.15-2.03)
≥ 1	349	42	2.19 (1.58-3.04)
Mammography***			
Regular Users	752	20	1.00
Nonusers	894	43	3.00 (2.41-3.75)

$^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.0001$.

Table 3

Crude Odds Ratios for Late-Stage Disease
Comparing Nonusers with Regular Users by Race

	Black Women			White Women		
	Nonuser n (%)	Regular User n (%)	OR (95% CI)	Nonuser n (%)	Regular User n (%)	OR (95% CI)
Late-Stage Disease						
Yes	39 (64)	4 (21)	6.65 (1.96-22.53)	349 (42)	149 (20)	2.83 (2.25-3.56)
No	22 (42)	15 (79)		484 (58)	584 (80)	

Table 4

Crude and Adjusted Odds Ratios for Late-Stage Disease
Comparing Black with White Women by Prior Mammography Use

	Nonuser				Regular User			
	Black n (%)	White n (%)	Crude OR (95% CI)	Adjusted* OR (95% CI)	Black n (%)	White n (%)	Crude OR (95% CI)	Adjusted* OR (95% CI)
Late-Stage Disease								
Yes	22 (36)	484 (58)	2.46	2.54	4 (21)	149 (20)	1.05	1.34
No	39 (64)	349 (52)	(1.43-4.22)	(1.37-4.71)	15 (79)	584 (80)	(0.34-3.20)	(0.40-4.51)

*Adjusted for SEER area, age, marital status, income, and comorbidity.

Table 5

Odds of Late-Stage Disease among Blacks Compared to Whites from Logistic Regression Analysis

Variables in Model	Odds Ratio (95% CI)	% Change in Odds Ratio[+]
1. Black Race	2.49 (1.59-3.92)	-
2. Black Race, Sociodemographic[*]	2.35 (1.42-3.89)	-9.40
3. Black Race, Comorbidity	2.56 (1.62-4.05)	+4.70
4. Black Race, Mammography Use	2.05 (1.29-3.26)	-29.53

[*]Sociodemographic variables include age, marital status, and income.
[+]Represents percent change in estimated odds ratio for black race compared with the unadjusted odds ratio from Model 1.
% change in OR = [(adjusted OR-unadjusted OR)/unadjusted OR-1.00] x 100.

Table 6

Odds of Late-Stage Disease among Blacks Compared to Whites from Hierarchical Logistic Regression Analysis

Variables in Model	Odds Ratio (95% CI)	% Change in Odds Ratio[+]
1. Black Race	2.49 (1.59-3.92)	-
2. Black Race, Sociodemographic[*], Comorbidity	2.47 (1.48-4.11)	-
3. Black Race, Sociodemographic[*], Comorbidity, Mammography Use	2.30 (1.36-3.88)	-11.56

[*]Sociodemographic variables include age, marital status, and income.
[+]Represents percent change in estimated odds ratio for black race in Model 3 compared with Model 2.
% change in OR = [(Model 3 OR-Model 2 OR)/Model 2 OR-1.00] x 100

Bivariate Associations with Mortality
Comparing Nonusers with Regular Users by Race (n=1,484)

Variable	White (n=1,413) RR (95% CI)		Black (n=68) RR (95% CI)		Total RR (95% CI)	
Race						
White					1.00	
Black					1.52	(1.07-2.16)
SEER Area						
Seattle	1.00		1.00		1.00	
Connecticut	1.43	(1.15-1.76)	1.07	(0.28-4.05)	1.43	(1.16-1.76)
Atlanta	1.41	(1.09-1.84)	0.82	(0.24-2.74)	1.45	(1.14-1.86)
Year of Diagnosis						
1987	1.00		1.00		1.00	
1988	0.85	(0.68-1.05)	0.51	(0.22-1.17)	0.82	(0.67-1.01)
1989	0.64	(0.50-0.81)	0.66	(0.27-1.58)	0.63	(0.50-0.80)
Age at Diagnosis						
67-74	1.00		1.00		1.00	
75-84	1.62	(1.32-1.99)	1.08	(0.50-2.33)	1.59	(1.30-1.94)
≥ 85	3.70	(2.90-4.71)	1.65	(0.64-4.24)	3.55	(2.81-4.94)
Married at Diagnosis						
No	1.00		1.00		1.00	
Yes	0.55	(0.45-0.67)	1.78	(0.73-4.33)	0.56	(0.46-0.69)
Median Income of Zip Code						
≥ $15,000	1.00		1.00		1.00	
< $15,000	1.06	(0.83-1.36)	0.90	(0.42-1.91)	1.13	(0.90-1.41)
Comorbidity Score						
No Hospitalizations	1.00		1.00		1.00	
0	0.92	(0.71-1.20)	1.73	(0.62-4.81)	0.95	(0.74-1.23)
≥ 1	1.89	(1.44-2.50)	3.54	(1.26-9.96)	1.98	(1.51-2.59)
Mammography						
Regular User	1.00		1.00		1.00	
Nonuser	3.12	(2.52-3.87)	2.54	(0.89-7.23)	3.13	(2.53-3.85)
Stage at Diagnosis						
Early	1.00		1.00		1.00	
Late	2.96	(2.46-3.54)	2.80	(1.22-6.47)	2.97	(2.49-3.54)

Table 8

Risk of Death among Black Compared with White Women
in Selected Stratified[+] Proportional Hazards Models

Variables in Model	RR (95% CI)
1. Black Race	1.52 (1.07-2.16)
2. Black Race, Mammography Use	1.27 (0.88-1.84)
3. Black Race, Stage	1.06 (0.73-1.55)
4. Black Race, Stage, Mammography Use	0.99 (0.68-1.45)
5. Black Race, Stage, Sociodemographic[*], Comorbidity, Mammography Use	0.96 (0.64-1.43)

[+]Models were stratified on SEER area.
[*]Sociodemographic variables include age, year of diagnosis, marital status, and income.

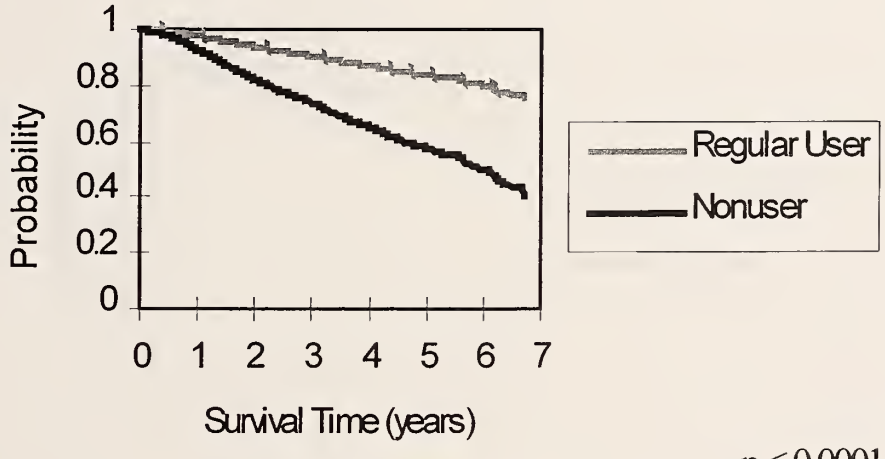
Table 9

Relative Risk of Death Comparing Mammography Nonusers with Regular Users for Women with Early and Late Stage at Diagnosis

	Mammography Use (Nonuser vs Regular User)	
	Crude Relative Risk	Adjusted* Relative Risk
Stage at Diagnosis		
Early	2.35 (1.76-3.15)	1.76 (1.30-2.41)
Late	2.82 (2.04-3.92)	2.25 (1.59-3.17)

+Models were stratified on SEER area.
*Adjusted for race, age, year of diagnosis, marital status, income, and comorbidity.

Figure 1. Survival Curves for Nonusers and Regular Users



$p < 0.0001$

Figure 2. Survival Curves for Nonusers and Regular Users Among Women with Early-Stage Disease

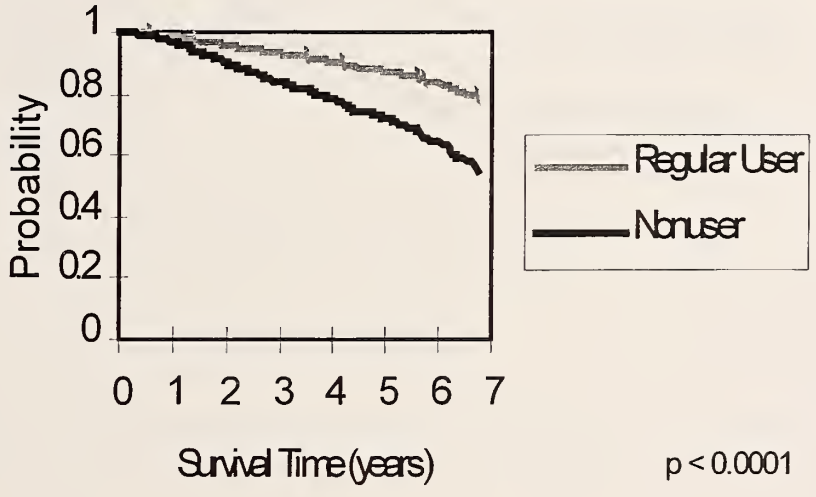
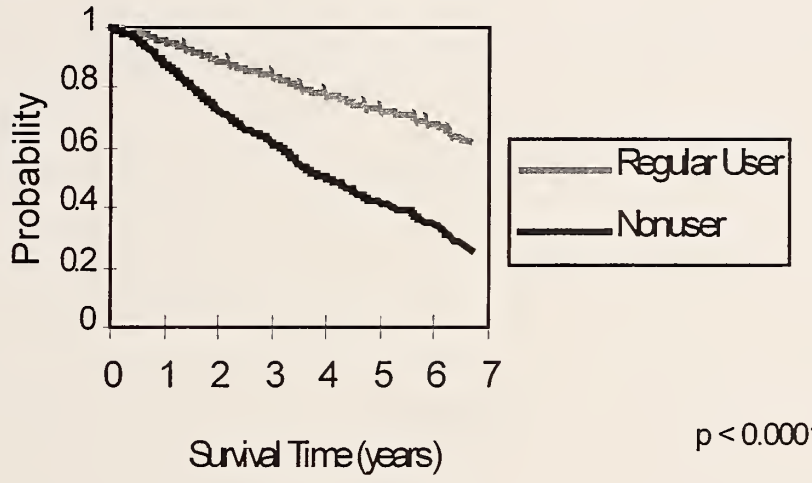


Figure 3. Survival Curves for Nonusers and Regular Users Among Women with Late-Stage Disease



APPENDIX

Table A-1

Characteristics of the Study Sample (n=1646) by Prior Mammography Use

	N	% Nonuser	% Regular User
Race***			
White	1566	53	47
Black	80	76	24
SEER Area***			
Connecticut	763	58	42
Seattle	543	41	59
Atlanta	340	68	32
Age at Diagnosis***			
67-74	800	47	53
75-84	657	55	45
≥ 85	189	82	18
Married at Diagnosis***			
No	1017	60	40
Yes	629	45	55
Median Income of Zip Code			
≥ $15,000	1357	58	42
< $15,000	276	54	46
Comorbidity Score***			
No Hospitalizations	338	55	45
0	959	49	51
≥ 1	349	67	33

$^{***}p < 0.001$

Table A-2

Risk of Death among Black Compared with White Women in Hierarchical Stratified[+] Proportional Hazards Models

Variables in Model	RR (95% CI)
Black Race	1.52 (1.07-2.16)
Black Race, Sociodemographic[*]	1.38 (0.93-2.04)
Black Race, Comorbidity	1.47 (1.03-2.09)
Black Race, Stage	1.14 (0.80-1.62)
Black Race, Mammography Use	1.24 (0.87-1.76)
Black Race, Stage, Sociodemographic[*]	1.06 (0.71-1.57)
Black Race, Stage, Comorbidity	1.09 (0.77-1.56)
Black Race, Stage, Mammography Use	0.97 (0.68-1.39)
Black Race, Stage, Sociodemographic[*], Comorbidity	1.00 (0.67-1.49)
Black Race, Stage, Sociodemographic[*], Comorbidity, Mammography Use	0.96 (0.65-1.43)

[+]Models were stratified on SEER area.
[*]Sociodemographic variables include age, year of diagnosis, and income.

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